# HARBOR SEAL POPULATION TRENDS IN THE KETCHIKAN, SITKA, AND KODIAK AREAS OF ALASKA, 1983-1999

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## INTRODUCTION

In the Gulf of Alaska and Prince William Sound (PWS) regions of Alaska, harbor seal (*Phoca vitulina richardsi*) numbers declined substantially from the late 1970s through the early 1990s (Pitcher 1990, Hoover-Miller 1994, Frost *et al*. 1999, Jemison and Pendleton 2001). A sympatric species of pinniped, the Steller sea lion (*Eumetopias jubatus*), also declined greatly in the Gulf of Alaska and Aleutian Islands during this period and was classified as "endangered" in the western portion of its range under the Endangered Species Act in May 1997. In Southeast Alaska (SE), harbor seal numbers appear to be increasing or stable in recent years and seals are thought to be relatively abundant (Small *et al*. 1998). Likewise, Steller sea lion numbers appear stable in SE (Calkins *et al*. 1997). However, new analyses of land-based and aerial counts in Glacier Bay (northern SE) indicate a 25–48% decline in harbor seal numbers from 1992 – 1998 (Mathews and Pendleton 2000).

The Alaska Department of Fish and Game (ADF&G) established harbor seal population trend routes in the Ketchikan and Sitka areas of SE (Figs. 1-3) and in PWS in 1983 (Calkins and Pitcher 1984). ADF&G surveyed the three aerial trend routes in 1984 (Pitcher 1986), but then routes were not surveyed again until the Ketchikan and PWS routes were flown in 1988 (Pitcher 1989). Although the PWS route was flown annually after 1988, the Ketchikan and Sitka routes were not surveyed again until 1993 when the National Marine Fisheries Service (NMFS) surveyed the entire SE region as part of their first statewide abundance survey (Loughlin 1994), including the areas where both the Ketchikan and Sitka trend routes are located. Beginning in 1993, ADF&G received funding from NMFS to investigate declining harbor seal populations, and ADF&G has subsequently conducted annual surveys of the Ketchikan (1994-1996, 1998) and Sitka routes (1995-1999). The Ketchikan route is currently surveyed on a biennial basis, due to low variation associated with a long-term increasing trend. NMFS surveyed the Kodiak Archipelago in 1992, also as part of their first statewide survey (Loughlin 1993), and a Kodiak trend route was established by ADF&G in 1993 that used some of the sites counted by NMFS (Figs. 1, 4). The Kodiak trend route was subsequently surveyed annually by ADF&G from 1994-1999. This chapter presents current population trend estimates through 1999 for the Ketchikan, Sitka, and Kodiak routes, and discusses the effect of covariates (*e.g.*, date, time of day) on those trends.

## METHODS

### *Aerial Surveys*

Each trend route consisted of 16 to 30 harbor seal haulout sites that were surveyed with single engine float equipped aircraft during the molting period in late August and early September. Surveys were usually conducted between two hours before and two hours after low tide, at an altitude of 200-300 m unless weather conditions required lower altitudes. After locating hauled out harbor seals, the aircraft circled the site and the observer visually counted all seals (including those in the water near haulouts), using binoculars when necessary, and then took 35mm color slide photographs (ASA 400) with an 80-200mm zoom lens for groups of >10-15 seals. The time was recorded when seals at each site were counted, such that the tide height at each site during the survey could later be estimated based on the nearest tide station. Survey times were not recorded for the 1983 Sitka survey, and therefore those counts are not included in the analysis. We attempted to conduct 5-7 replicate surveys per year for each route, with each site surveyed unless prohibited by poor weather. Seal numbers were later counted from projected slide images on a white surface. The replicate counts for each trend site obtained prior to 1997 were reported previously by Lewis *et al*. (1996), Small *et al*. (1997), and Small *et al*. (1998).

### *Trend Analysis*

An estimate of population trend based on counts must account for the variation in those counts that results from both real changes in population abundance and factors that affect the proportion of the population visible during surveys. Rather than assume that a constant proportion of seals were visible, and thus observed during each survey, we modeled counts as a function of environmental covariates; e.g., survey date and time of day. We then estimated the population trend from a series of annual counts using overdispersed multinomial models (Link and Sauer 1997). With this type of model, counts, $Y_{ij}$ ($i$ indicates site and $j$ indicates replicate) are assumed to be overdispersed Poisson random variables (i.e., negative binomial) with expected values ($m_i$) that have the relationship $\ln(m_i) = h(_i) * gi(\underline{x}) * fi(t)$. In this equation, $h(_i)$ represents site effects that are treated as a multiplicative nuisance parameter, $g_i(\underline{x})$ is a loglinear function of the environmental covariates ($\underline{x}$) that are unrelated to population change, and $f_i(t)$ is the population trajectory with t indicating year. The population trajectory can be thought of as a smoothed curve proportional to the actual population sizes across years. Because trajectories were not always linear (*i.e.*, the rate of change varies through time) on the log scale, we defined population trend (*i.e.*, lambda, finite rate of increase) as the geometric mean rate of change over the interval of interest. Trend is therefore a single-number summary of the average change in the trajectory. Because the exact proportion of the population counted can not be determined without additional data, graphs of the population trajectories were scaled arbitrarily, such that they went through the adjusted count in the mid year of the dataset, or, when there was an even number of years, through the average of the adjusted counts in the two middle years.

We used four environmental covariates in our analysis: survey date, time to solar-midday, time to low tide, and tide height at each site when surveyed. Frost *et al.* (1999) used these same covariates in their estimation of harbor seal population trend in PWS, though they used categorical versions of these variables whereas we used continuous forms. In addition to the linear form of the four covariates, we also included quadratic effects (*e.g.*, $date^2$) for each and also $year^2$, and allowed the effect of tide height to vary by site (*i.e.*, site*tide height interaction). Models with a single tide height parameter (*i.e.*, the effect of tide is the same at all sites) are special cases of site*tide interaction models (*i.e.*, tide effect varies among sites); each of the models tested included either a single tide effect or the site*tide interaction. The quadratic and interaction covariates were chosen because of known or suspected patterns in seal haulout behavior. Models with both linear and quadratic population trajectories (*i.e.*, change in population size across years on the log scale) were tested.

We fit all combinations of covariates and trajectories for a total of 768 models. Final trend estimates and standard errors were obtained as a weighted average of trend estimates from the individual models with weights based on corrected Akaike's Information Criteria (AICc) (Hurvich and Tsai 1989, Burnham *et al.* 1995). This model averaging procedure (Burnham and Anderson 1998) incorporates the uncertainty in which model is most appropriate into the trend estimate and its variance. Approximate 95% confidence intervals for trend estimates were computed as the weighted estimate $\pm$ 1.96 * weighted standard error. A trend estimate was considered statistically significant when the associated confidence interval did not include zero.

To evaluate the effect of the covariates on the final trend estimate, we computed model-averaged trend estimates from subsets of the models not containing individual covariates (*e.g.*, without date and $date^2$). We then calculated the percent change in model-averaged trend by comparing the subset of models with the covariate omitted to the full set of models. To examine how counts responded to the range of values observed for the individual covariates, we predicted counts based on the covariate coefficients from the final averaged model, scaled to the observed mean count for each trend route.

## RESULTS

Based on counts obtained during the 16 year period between 1983-1998 (Table 1), harbor seal numbers in the Ketchikan survey area exhibited a significant increase of 7.4%/year, representing a cumulative increase of 293.4% (Table 2; Fig. 5A). A slightly lower significant increase of 5.6%/year was estimated for 1994-1998, a 23.9% increase over 4 years (Fig. 5B). Counts in Sitka increased slowly over the 15 year period between 1984-1999, with an annual increase of 1.1%/year for a cumulative increase of 21.4%. A very similar trend of 0.9%/year (not significant) was estimated for the Sitka route during 1995-1999, an increase of 3.6% for the 4 year period. A significant 5.6%/year increase in counts was recorded for the Kodiak survey area from 1993-1999, representing a 38.8% increase over the 6 year period.

Environmental covariates substantially influenced population trend estimates for each survey route. Trend estimates were most sensitive to survey date, as the largest percent change in trend estimates was observed when survey date was omitted (Table 3). Predicted counts were highest on the earliest recorded survey date for both the Sitka (18 August) and Kodiak (15 August) routes, with counts decreasing approximately 12% and 23% over the next ten days, respectively (Fig. 6A). Predicted counts were highest for the Ketchikan route around 21 August, with a 15% decrease ten days earlier or later. Time to midday also influenced population trend substantially, as the Ketchikan 1983-1998 trend estimate was more sensitive to the omission of time to midday than survey date. Predicted counts were highest near midday for both Ketchikan and Sitka, whereas predicted counts were highest approximately 1.5 hours after midday for Kodiak (Fig 6B). Trend estimates were influenced relatively less by time to low tide. For Sitka and Kodiak, predicted counts were highest near low tide, with a gradual decrease in counts on either side of low tide (Fig. 6C). For Ketchikan, a linear decrease in predicted counts was observed from several hours before to several hours after low tide. The influence of tide height on trend estimates was less than any other covariate. In addition, the influence of tide height was site-specific in only the Ketchikan 1983-1998 trend estimate, where predicted counts decreased gradually on either side of mean lower low water (MLLW; i.e., 0.0 ft). Predicted counts exhibited no consistent relationship with tide height among sites in each of the remaining four averaged models.

## DISCUSSION

The 5.6% annual increase in seals counted on the Kodiak trend route during 1993-1999 represents the first documented increase in harbor seal numbers over a relatively broad area in the Gulf of Alaska. Previously, two substantial population declines had been recorded in the Gulf of Alaska. First, counts decreased approximately 85% from 1976 to 1988 on the Southwest Beach haulout of Tugidak Island (Fig. 4; #28), a site that formerly had one of the largest concentrations of harbor seals in the world (Pitcher 1990). Pitcher (1990) reported a –21%/year decline from 1976–1978, and a less dramatic decline (-7%/year) from 1978–1988. Counts of seals stabilized during the late 1980s to early 1990s and increased at 4.9%/year from 1994–1999 (Jemison and Pendleton 2001). Second, a decrease of 63% during 1984-1997 has been observed in eastern and central PWS (Frost *et al*. 1999), with more recent (1995-1999) counts indicating population stability (K. Frost, *pers. comm*.). Complete counts of the 30 haulout sites that comprise the Kodiak trend route were not conducted until that route was established in 1993. However, maximum counts of seals at five of the larger haulouts sites on the Kodiak trend route were obtained in the mid 1970s (Pitcher and Calkins 1979). A comparison between mid 1970s counts at these five sites and maximum counts from the early to mid 1990s at these sites indicate a mean decline of 66% (range 35% to 79%), suggesting a significant decline occurred throughout the eastern Kodiak Island area (Lewis *et al*. 1996). In contrast to the changing population trends observed in both the PWS and Kodiak regions, morphometric indices of harbor seal condition appear to have remained relatively constant from the mid 1970s through the mid 1990s in the Gulf of Alaska (Fadely 1997). For the Kodiak area, such stable condition indices suggest changes in population trend followed similar changes in carrying capacity (Gerrodette and DeMaster 1990). Specifically, a sharp decrease in carrying capacity from the mid-1970s through the late 1980s, followed by a period of stabilization in the early 1990s, and most recently a gradual increase in carrying capacity.

In the Ketchikan area of SE, our counts indicate that the number of harbor seals increased 7.4% annually during 1983-1998, followed by a slightly lower rate of growth (5.6%/year) during the more recent 1994-1998 period. In the Sitka area of SE, a lower rate of growth was observed during both the 1984-1999 period (1.1%/year), as well as the more recent 1995-1999 period (0.9%/year). In contrast, harbor seal numbers south of the Ketchikan trend route area, in the Strait of Georgia, British Columbia, increased 11.5% annually during the 1970s and 1980s, followed by a more moderate rate of growth in the early 1990s; currently, numbers appear stable (Olesiuk *et al.* 1990, Olesiuk 1999). In Glacier Bay, north of the Sitka trend route area and also in SE (Fig. 1), the number of harbor seals increased between 1975 and the mid 1980s, but decreased 7.5%/year from 1992-1998 (Mathews and Pendleton 1997, Mathews and Pendleton 2000). Combined, these spatially and temporally disparate population trends within SE and British Columbia suggest harbor seals are responding to factors that may vary substantially across regions. For example, Olesiuk (1999) suggests British Columbia seal populations have stabilized at historic levels following a period of intense commercial harvesting in the 1960s. The commercial harvest in British Columbia was likely substantially greater than in SE during the 1960s, yet there are no harvest data suggesting harvests were greater in the Ketchikan area compared to Sitka (P. Olesiuk *unpublished data*, Wolfe and Mishler 1993); yet, seal numbers have nearly tripled near Ketchikan, remained relatively stable near Sitka, and recently declined in Glacier Bay.

Trend estimates represent an important index to the dynamics of populations, yet they do not identify the causative factors driving the estimated trend. Estimates of survival, reproduction, and dispersal would ultimately be most informative in discerning the basis for changes in numbers over time (Eberhardt and Siniff 1977), and the recent photo identification studies on Tugidak Island (Crowley *et al*. 2001, Hastings *et al*. 2001) are designed to generate such vital parameter estimates. However, to conduct such studies in all areas where information on harbor seal population trend may be needed in Alaska is not practical or feasible, and thus for most trend estimates, vital rates will not be available to interpret changes in population trend. Additional information on auxiliary variables, however, can assist in the evaluation and improvement of trend estimates (Eberhardt *et al*. 1999), and also provide correlative insights to interpreting changes in population trends. For example, Sydeman and Allen (1999) interpreted the relationship between changes in annual oceanographic conditions (*i.e.*, sea-surface temperature and upwelling indices) and harbor seal numbers in central California as an indication of the role of food availability. As mentioned above, we interpret changes in harbor seal population trend along with stable body condition from the mid-1970s through 1999 in the eastern Kodiak Island area as an indication of concurrent changes in carrying capacity. Thus, data on pertinent auxiliary variables can potentially provide useful information in determining what factors may be involved with changes in seal numbers, and thus should be collected when seals are counted.

Environmental covariates substantially influenced the number of seals hauled out at sites within each of our three aerial survey routes, and thus our estimates of population trend. Survey date had the largest influence on trend estimates for each route, followed by time to midday and time to low tide. However, the relative influence of the covariates varied among the three routes and for the two time periods for which Ketchikan and Sitka trend estimates were based. Specifically, time to midday had the largest effect on the overall 15-year (1983-1998) Ketchikan trend estimate, whereas for the most recent 5-year period (1994-1998) date had the largest effect, followed by time to low tide and time to midday. Date had the greatest effect on Sitka trend estimates for both the overall 15-year (1984-1999) period as well as the recent 4-year period (1995-1999); the covariate with the next strongest influence on trend was time to low tide during 1984-1999, and time to midday during 1995-1999. The relative influence of covariates on a harbor seal population trend estimate for PWS reported by Frost *et al.* (1999), using a similar analysis, was different than what we observed in any of our analyses: time of day, date, and time to low tide. Tide height consistently had the least influence among the covariates we measured, and was not significant in the PWS trend analysis (Frost *et al.* 1999).

The consistent influence of environmental covariates on our harbor seal population trend analyses, and those of others (Frost *et al.* 1999, Olesiuk 1999, Mathews and Pendleton 2000, Jemison and Pendleton 2001, Jemison *et al.* 2001), provides further support for the need to determine how such covariates affect harbor seal counts and subsequent population trend estimates. Our results also demonstrate how the influence of covariates can vary both spatially and temporally, as predicted by Frost *et al*. (1999), likely due to site-specific variation in the factors that affect seal behavior (e.g., habitat, disturbance). Ver Hoef and Frost (*in review*) describe site-specific variation among the trend sites of the PWS survey route based on a Bayesian hierarchical model, providing additional evidence for fine scale spatial differences in the influence of covariates. These numerous studies have documented the statistically significant influence of covariates, and also demonstrate that the magnitude of that influence on population trend estimates is biologically significant and thus important for the management and conservation of harbor seals. Further, priority should be placed on determining the relative effect of covariates on trend estimates (e.g., Table 3) rather than attempting to interpret seal haulout behavior from aerial counts by estimating specific levels of probability and statistical significance of each covariate (Johnson 1999).

Long term monitoring at land based sites in Alaska, with multiple daily counts collected over the entire pupping and molting periods, has provided insights on additional factors that can influence population trend estimates. For example, Jemison and Pendleton (2001) observed that maximal counts on Tugidak Island during the molting period were 2-4 weeks later in the late 1970s than in the late 1990s, suggesting a substantial temporal shift in the molting period. Additionally, Daniel *et al*. (2001) reported age- and sex-specific differences in the timing of molting for seals on Tugidak, further supporting the need to account for such differences in survey design as discussed by Härkönen *et al*. (1999). Jemison and Kelly (2001) reported differences in the ratio of the number of seals hauled out during the pupping and molting periods across decades, and suggested the ratio of seals hauled out may be related to food availability or changes in the demographic structure of the population. These factors, and others, can both decrease accuracy and introduce bias in population trend estimates. To examine these concerns, Adkison *et al*. (2001) investigated the experimental design of Alaska harbor seal population surveys by employing an operating model approach to simulate harbor seal population dynamics and haulout behavior that incorporated numerous factors that potentially affect trend estimates generated from aerial surveys. Such a simulation approach and subsequent sensitivity analysis can determine the magnitude of the bias and decreased precision caused by specific factors, and should be utilized to increase the robustness of survey experimental design.

## ACKNOWLEDGEMENTS

We thank the individuals who conducted aerial surveys from which the data used in this report were generated, particularly Jon Lewis, Dennis McAllister, Ken Pitcher, and Una Swain. Numerous pilots flew their aircraft for extended periods, often in adverse conditions, and also assisted us in locating seals; their efforts are greatly appreciated. Funding for the 1983, 1984, and 1988 trend surveys was provided by the Marine Mammal Commission. Trend surveys conducted since 1993 have been supported through NOAA grants NA57FX0367 and NA87FX0300 to the ADF&G for harbor seal investigations in Alaska.

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Table 1. Annual mean counts of harbor seals from population trend routes in the Ketchikan, Sitka, and Kodiak areas in Alaska, 1983-1999. An adjusted index for each count was calculated after adjusting for the environmental covariates present in the final model used to estimate population trend, and then scaled to the year in the middle of available counts (see text).

| | Ketchikan | | Sitka | | Kodiak | |
|---|---|---|---|---|---|---|
| Year | Mean Count | Adjusted Index | Mean Count | Adjusted Index | Mean Count | Adjusted Index |
| 1983 | 1059 | 977 | -- | -- | -- | -- |
| 1984 | 1554 | 1168 | 1273 | 1533 | -- | -- |
| 1988 | 1821 | 1625 | -- | -- | -- | -- |
| 1993 | -- | -- | -- | -- | 2522 | 3129 |
| 1994 | 2228 | 2228 | -- | -- | 3172 | 3478 |
| 1995 | 2604 | 2533 | 2041 | 1822 | 3510 | 3855 |
| 1996 | 2706 | 2825 | 1602 | 1575 | 2584 | 3322 |
| 1997 | -- | -- | 2183 | 1749 | 3873 | 3674 |
| 1998 | 3146 | 2832 | 1862 | 1712 | 4319 | 4247 |
| 1999 | -- | -- | 2284 | 1872 | 4723 | 4876 |

Table 2. Harbor seal annual population trend estimates (%change/year) and associated 95% confidence limits, and cumulative % change for the Ketchikan, Sitka, and Kodiak areas in Alaska, 1983-1999

| Area | Years | N[1] | Trend (se) | 95% Confidence Limit | Cumulative % Change |
|---|---|---|---|---|---|
| Ketchikan | 1983-98 | 7 (16) | 7.4 (0.66) | 6.1 - 8.7 | 293.4 |
| Ketchikan | 1994-98 | 4 (16) | 5.6 (1.16) | 3.4 - 7.9 | 23.9 |
| Sitka | 1984-99 | 6 (20) | 1.1 (0.61) | -0.1 - 2.3 | 21.4 |
| Sitka | 1995-99 | 5 (21) | 0.9 (1.97) | -3.0 - 4.7 | 3.6 |
| Kodiak | 1993-99 | 7 (30) | 5.6 (0.92) | 3.8 - 7.4 | 38.8 |

[1]The number of years the route was surveyed and the number of sites within the route (in parentheses) during the time period that the population trend was estimated.

Table 3. Harbor seal annual population trend estimates with the omission of individual environmental covariates, for the Ketchikan, Sitka, and Kodiak areas in Alaska, 1983-1999.

| | Ketchikan | | | | Sitka | | | | Kodiak | |
|---|---|---|---|---|---|---|---|---|---|---|
| Covariate | 1983-98 | | 1994-98 | | 1984-99 | | 1995-99 | | 1993-99 | |
| Omitted[1] | Trend | % Change | Trend | % Change | Trend | % Change | Trend | % Change | Trend | % Change |
| | 7.4 | -- | 5.6 | -- | 1.1 | -- | 0.9 | -- | 5.7 | -- |
| Year[2] | 7.0 | -5.5 | 5.0 | -11.9 | 1.0 | -8.4 | 1.1 | 25.6 | 7.1 | 25.0 |
| Date | 7.5 | 0.8 | 10.0 | 76.9 | 3.3 | 194.1 | 2.9 | 228.3 | 8.7 | 53.7 |
| Time to midday | 5.7 | -22.7 | 7.1 | 26.0 | 1.9 | 6.0 | 2.0 | 129.9 | 8.1 | 43.5 |
| Time to low tide | 7.1 | -4.4 | 7.3 | 29.6 | 1.4 | 23.1 | 0.9 | 0.4 | 5.6 | -0.9 |
| Tide height | 7.2 | -3.3 | 5.5 | -1.2 | 0.4 | -15.2 | 1.1 | 25.6 | 7.1 | 24.8 |
| Site*Tide height | 7.4 | 0 | 5.6 | 0.3 | 0.7 | -42.5 | 0.8 | -10.3 | 6.2 | 8.8 |

[1]The linear and quadratic form of each covariate was omitted, except only the quadratic form of year was omitted.

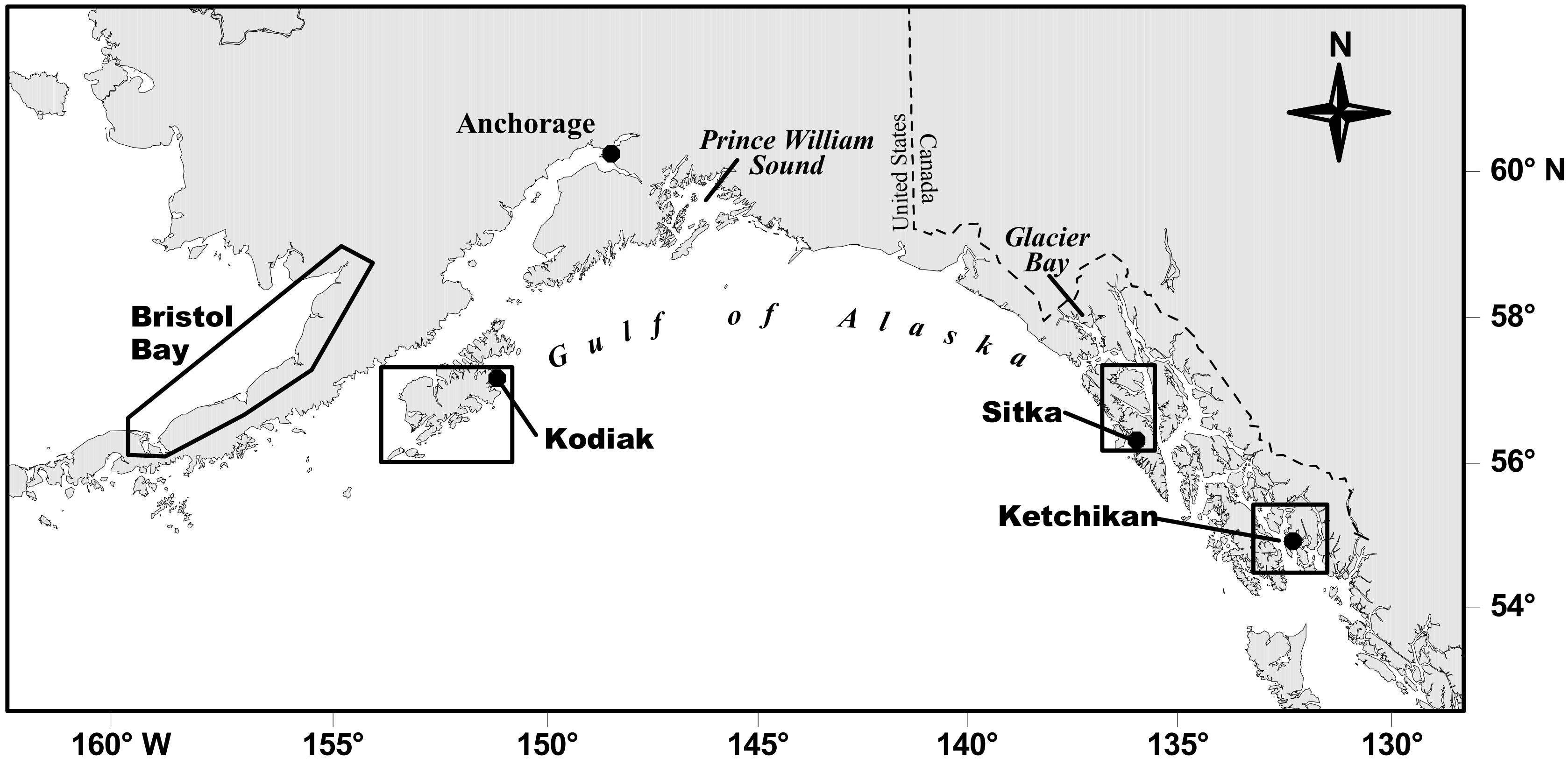


Figure 1. Location of the harbor seal population trend routes in the Ketchikan, Sitka, Kodiak, and Bristol Bay areas of Alaska.

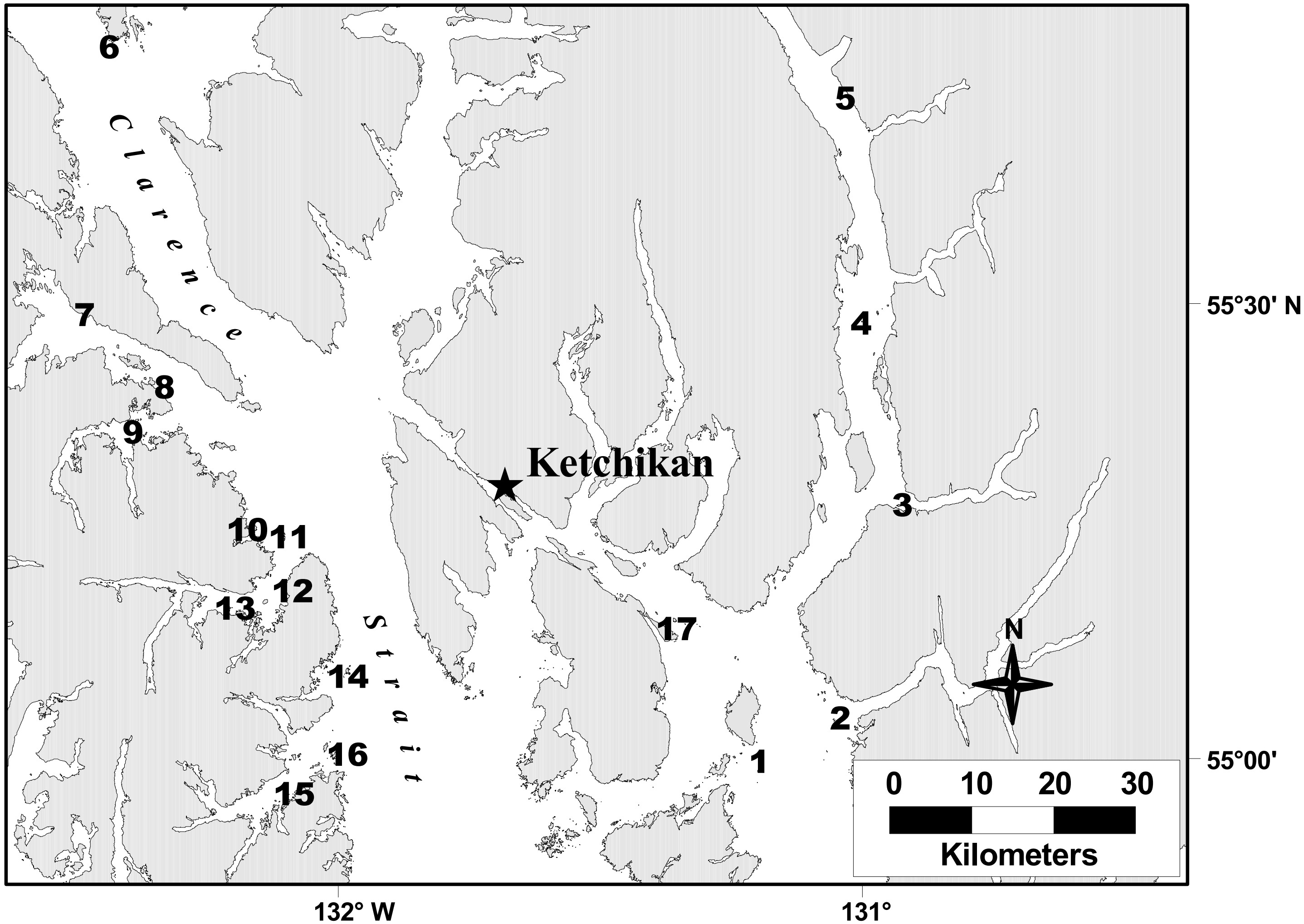


Figure 2. Location of the 16 haulout sites where counts of harbor seals were obtained during aerial surveys during 1983-1999 to estimate population trend near Ketchikan, Alaska. Site names are referenced in Appendix I.

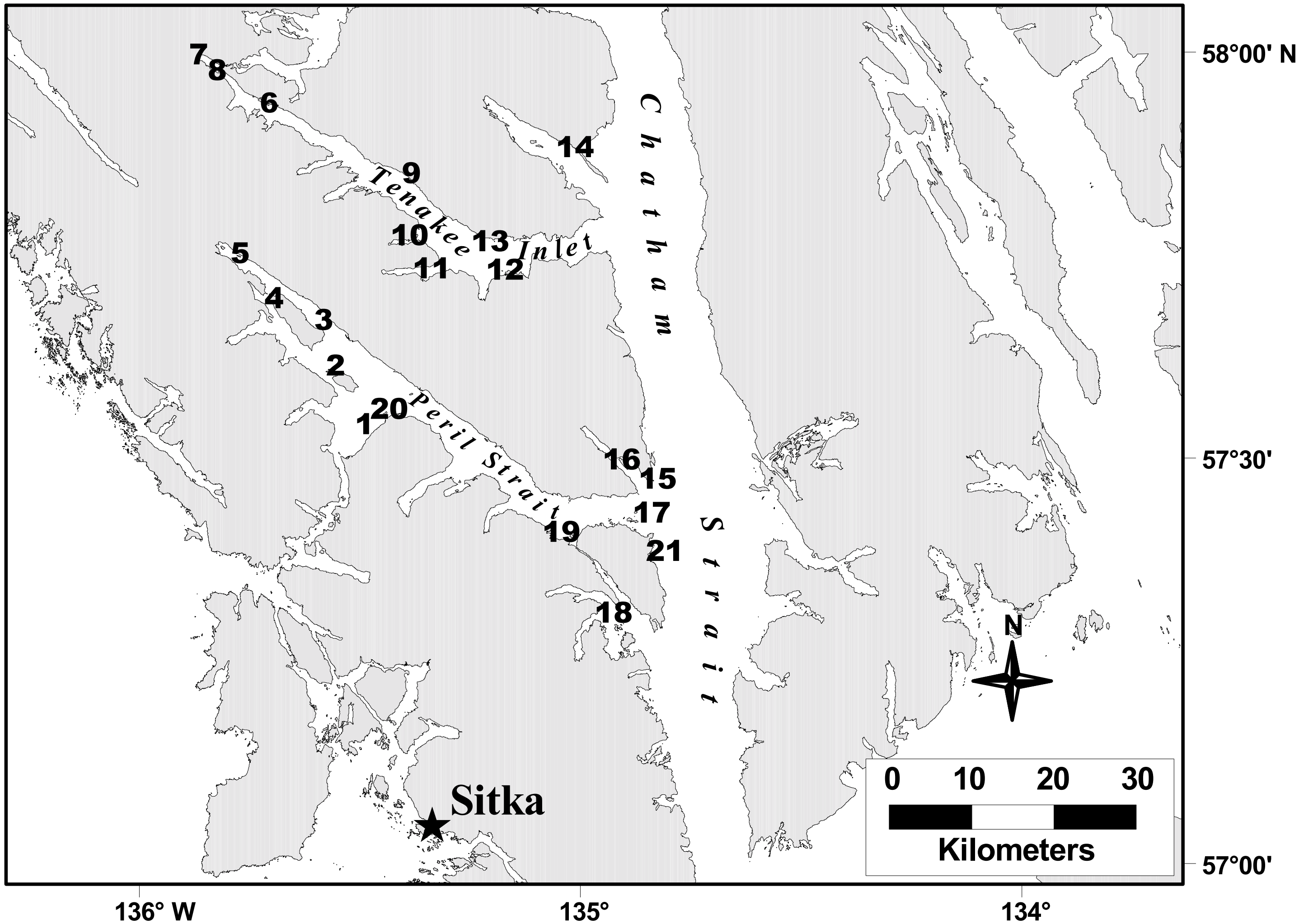


Figure 3. Location of the 21 haulout sites where counts of harbor seals were obtained during aerial surveys during 1984-1999 to estimate population trend north of Sitka, Alaska. Site names are referenced in Appendix II-III.

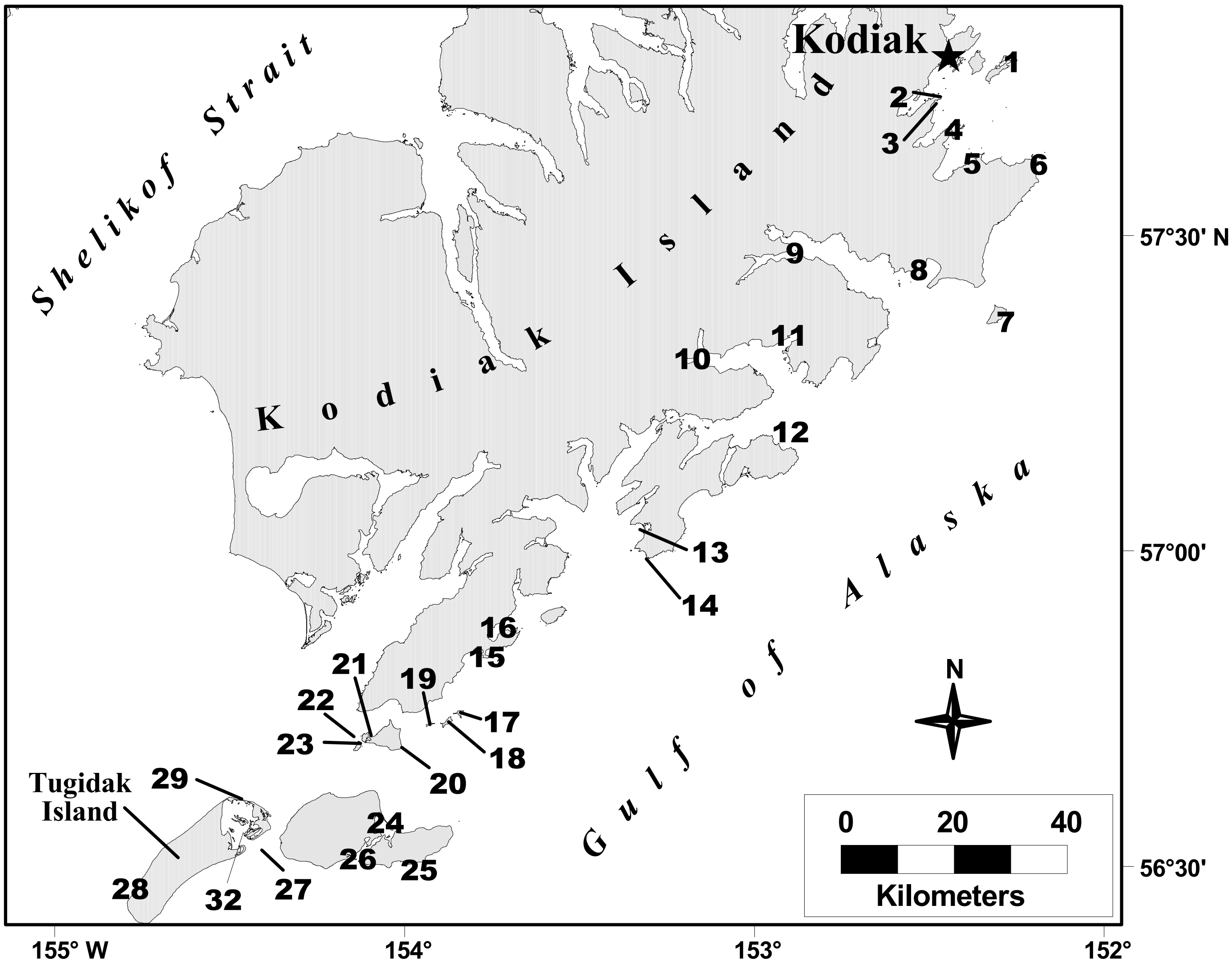


Figure 4. Location of the 30 haulout sites where counts of harbor seals were obtained during aerial surveys during 1993-1999 to estimate population trend for Kodiak Island, Alaska. Site names are referenced in Appendix IV-V.

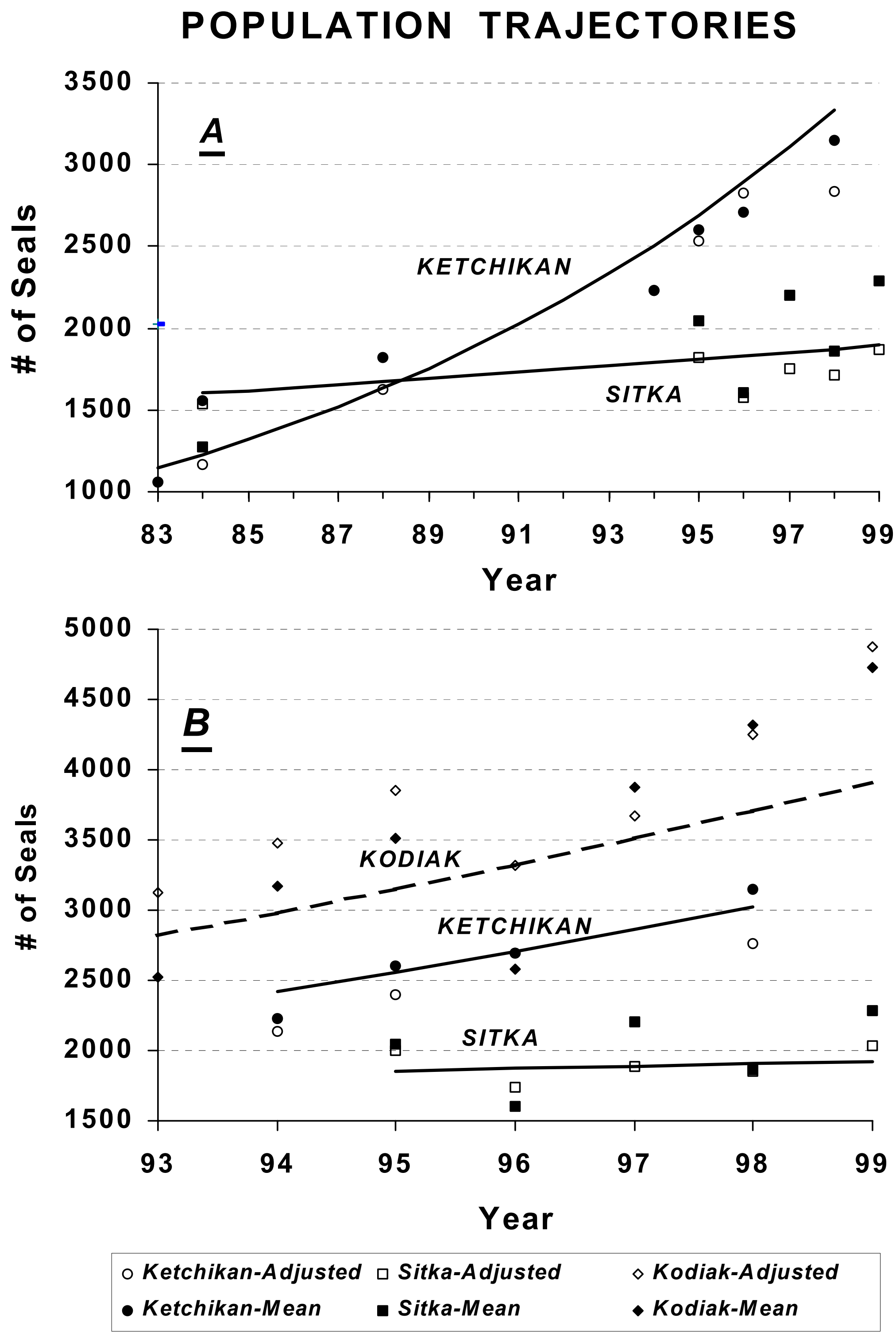


Figure 5. Harbor seal population trajectories for the Ketchikan, Sitka, and Kodiak areas in Alaska during 1983-1999 (A) and 1993-1999 (B). Trajectories were based on adjusted indices (open markers) derived from mean annual counts (solid markers) adjusted for environmental covariates.

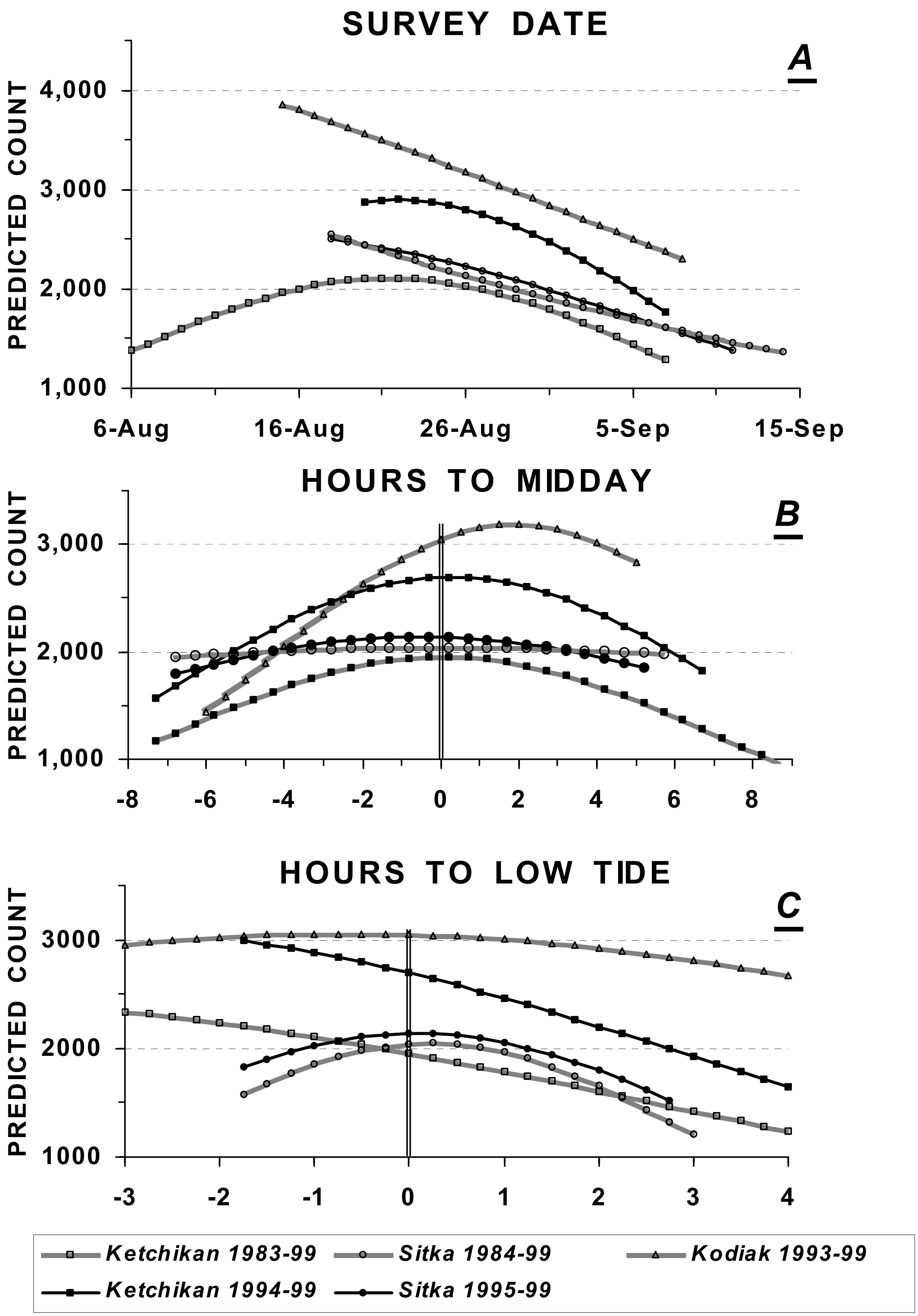


Figure 6. Predicted influence of survey date (A), hours to solar midday (B), and hours to low tide (C), on counts of harbor seals in the Ketchikan, Sitka, and Kodiak areas of Alaska, 1983-1999.

Appendix I. 1998 harbor seal aerial survey counts from the Ketchikan trend route.

| Site # | Site Name | 20-Aug | 21-Aug (morning) | 21-Aug (evening) | 22-Aug | 23-Aug | 24-Aug | 25-Aug | 26-Aug |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Whale Rock | 138 | 47 | 97 | 77 | 124 | 97 | 120 | |
| 2 | White Reef | 630 | 417 | 741 | 403 | 547 | 476 | 245 | 130 |
| 3 | Carp Island | 8 | 9 | 17 | 0 | 0 | 0 | 0 | |
| 4 | N Eddystone Rk | 653 | 235 | 331 | 209 | | 320 | 419 | |
| 5 | Channel Is | 756 | 351 | 389 | 214 | 389 | 301 | 285 | |
| 6 | Eagle Island | 532 | 488 | 534 | 492 | 669 | 426 | 504 | |
| 7 | Tolstoi Island | 111 | 104 | 103 | 104 | 110 | 97 | 81 | |
| 8 | Daisy Island | 55 | 128 | 135 | 146 | 180 | 182 | 68 | |
| 9 | McKenzie Is | 183 | 116 | 90 | 103 | 96 | 112 | 108 | |
| 10 | Clover Bay | 45 | 93 | 82 | 107 | 102 | 96 | 99 | |
| 11 | Skin Island | 30 | 3 | 38 | 41 | 40 | 28 | 14 | |
| 12 | Lancaster C | 24 | 0 | 19 | 3 | 16 | 172 | 0 | |
| 13 | E Dora Bay | 28 | 174 | 140 | 161 | 143 | 65 | 211 | |
| 14 | Wedge Island | | 252 | 290 | 323 | 312 | 119 | 308 | 328 |
| 15 | Moria Sound | | 327 | 253 | 353 | 338 | 114 | 423 | 213 |
| 16 | Whiterock Is | | 170 | 157 | 201 | 129 | 58 | 102 | |

Appendix II. 1998 harbor seal aerial survey counts from the Sitka area trend route.

| Site# | Site Name | 22-Aug | 23-Aug | 24-Aug | 25-Aug | 26-Aug | 8-Sep | 9-Sep | 10-Sep | 11-Sep |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Hoggatt | | 198 | 126 | 117 | 115 | 0 | 6 | | |
| 2 | Vixen | | 412 | 184 | 381 | 344 | 235 | 274 | | |
| 3 | Moser I N | | 44 | 38 | 54 | 47 | 41 | 23 | | |
| 4 | Southarm | | 22 | 11 | 0 | 7 | 21 | 24 | | |
| 5 | Northarm | | 56 | 53 | 82 | 59 | 36 | 0 | | |
| 6 | Long Bay | 131 | 185 | 123 | 149 | | 148 | 120 | | 81 |
| 7 | Head of Tenakee | 49 | 53 | 34 | 37 | | 102 | 109 | | 13 |
| 8 | Grassy | 148 | 148 | 197 | 123 | | 3 | 0 | | 65 |
| 9 | Mid I. S. | 13 | 13 | 13 | 26 | | 19 | 26 | | 16 |
| 10 | Saltry Bay | 0 | 0 | 0 | 0 | | 0 | 0 | | 0 |
| 11 | Crab Bay | 243 | | 218 | 174 | 190 | 143 | 9 | | 6 |
| 12 | Strawberry Rk | 66 | 94 | 74 | 33 | | | 95 | | 28 |
| 13 | Tenakee Rk | 230 | 286 | 271 | 267 | | | 122 | | 69 |
| 14 | Heide[1] | 171 | 267 | 235 | 252 | | 232 | 77 | | 170 |
| 15 | Pt Hayes | 50 | 53 | 62 | 64 | | 98 | 78 | 89 | |
| 16 | Traders | 104 | 69 | 80 | 87 | | 73 | 50 | 42 | |
| 17 | Midway | 20 | 27 | 16 | 40 | | 4 | 7 | 6 | |
| 18 | Plover | | 129 | 47 | 145 | 136 | 108 | 175 | | |
| 19 | Pt. Moses | | | | | | | 89 | | |
| 20 | Krugloi | | 0 | 36 | 30 | 52 | 27 | 44 | | |
| 21 | E. Cathrine I. | 33 | 25 | 44 | 29 | | 50 | 37 | 39 | |

[1]Site # 14 was previously named “Appletree” but changed to “Heidi Rock” in 1997 to conform to USGS maps and NOAA charts.

Appendix III. 1999 harbor seal aerial survey counts from the Sitka trend route.

| Site # | Site Name | 15-Aug | 16-Aug | 25-Aug | 27-Aug | 29-Aug | 30-Aug | 31-Aug |
|---|---|---|---|---|---|---|---|---|
| 1 | Hoggatt | 380 | 369 | 273 | 138 | 76 | 165 | 234 |
| 2 | Vixen | 408 | 446 | 372 | 309 | 198 | 381 | 339 |
| 3 | Moser I N | 54 | 43 | 19 | 2 | 12 | 13 | 5 |
| 4 | Southarm | 10 | 16 | 17 | 28 | 30 | 28 | 29 |
| 5 | Northarm | 31 | 35 | 19 | 0 | 58 | 75 | 2 |
| 6 | Long Bay | 253 | 303 | 229 | 180 | 48 | 112 | 178 |
| 7 | Head of Tenakee | 101 | 66 | 105 | 110 | 0 | 0 | 93 |
| 8 | Grassy | 0 | 46 | 0 | 0 | 107 | 100 | 0 |
| 9 | Mid I. S. | 13 | 8 | 16 | 23 | 20 | 21 | 38 |
| 10 | Saltry Bay | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | Crab Bay | 260 | 391 | 288 | 290 | 312 | 326 | 220 |
| 12 | Strawberry Rk | 29 | 31 | 74 | 74 | 98 | | 51 |
| 13 | Tenakee Rk | 207 | 234 | 199 | 249 | 159 | | 239 |
| 14 | Heide[1] | 226 | 236 | 208 | 163 | 226 | | 173 |
| 15 | Pt Hayes | 80 | 94 | 105 | 92 | 127 | 76 | 108 |
| 16 | Traders | 65 | 156 | 43 | 76 | 96 | 97 | 97 |
| 17 | Midway | 80 | 87 | 47 | 51 | 0 | 4 | 25 |
| 18 | Plover | 287 | 116 | 156 | 162 | 85 | 105 | 191 |
| 19 | Pt. Moses | 58 | 102 | 29 | 98 | 141 | 105 | 0 |
| 20 | Krugloi | 0 | 0 | 0 | 51 | 47 | 68 | 70 |
| 21 | E. Cathrine I. | 14 | 17 | 20 | 36 | 38 | 40 | 30 |

[1]Site #14 was previously named “Appletree” but changed to “Heidi Rock” in 1997 to conform to USGS maps and NOAA charts.

Appendix IV. 1998 harbor seal aerial survey counts from the Kodiak trend route.

| Site# | Site Name | Aug-15 | Aug-18 | Aug-26 | Aug-27 | Aug-28 | Aug-29 |
|---|---|---|---|---|---|---|---|
| 1 | Long I | 84 | 60 | 33 | 37 | 43 | 38 |
| 2 | Cliff Pt | 38 | 30 | 9 | | 20 | 8 |
| 3 | Broad Pt | 0 | 2 | 0 | 1 | 0 | 0 |
| 4 | Kalsin B | 155 | 131 | 127 | 45 | 176 | 0 |
| 5 | Ugak I | 698 | 576 | 358 | 344 | 378 | 421 |
| 6 | W Pasagshak | 209 | 186 | 117 | 97 | 112 | |
| 7 | Upper Ugak B | 125 | 94 | 0 | 0 | 0 | 8 |
| 8 | Shearwater B | 172 | 111 | 77 | | 111 | 92 |
| 10 | Black Pt | 288 | 198 | 176 | 99 | 111 | 138 |
| 11 | Rolling B | 32 | 45 | 34 | | 49 | 39 |
| 12 | O Kaguyak | 13 | 9 | 4 | 4 | 4 | 1 |
| 13 | Geese I N | 351 | 359 | 241 | 249 | 205 | 287 |
| 14 | mid Geese I | 103 | 73 | 21 | 11 | 14 | 31 |
| 15 | S. Geese I | 6 | 5 | 18 | 24 | 23 | 11 |
| 16 | Aiaktalik L | 15 | 26 | 29 | 26 | 32 | 24 |
| 17 | Aiaktalik I | 101 | 67 | 62 | 53 | 64 | 55 |
| 18 | Sunstrom I | 15 | 7 | 9 | 14 | 9 | 7 |
| 19 | N Sitkinak Lgn | 185 | 167 | 158 | 138 | 119 | 99 |
| 20 | Sitkinak I SE | 295 | 287 | 232 | 98 | 167 | 82 |
| 21 | S Sitkinak Lgn | 143 | 182 | 140 | 53 | 141 | 183 |
| 22 | SE Tugidak Bars | 416 | 354 | 273 | 234 | 276 | 223 |
| 23 | SW Tugidak | 1385 | 906 | 733 | 399 | 719 | 970 |
| 24 | N Tugidak (out) | 366 | 0 | 0 | 0 | 0 | 210 |
| 25 | NE Tugidak (out) | 422 | 249 | 107 | 157 | 399 | 31 |
| 26 | Tugidak Lgn in | 256 | 271 | 268 | 177 | 105 | 196 |
| 27 | NNE Tugidak (out) | 0 | 703 | 598 | 281 | 169 | 329 |
| 28 | Upper Kiliuda | 115 | 97 | 108 | 105 | 106 | 104 |
| 29 | Women's Bay Mkr | 42 | 43 | 42 | 44 | 46 | 10 |
| 32 | I Kaguyak | 30 | 17 | 13 | 16 | 16 | 26 |

Note: Site #9 (Barnabas Rks) was not surveyed in 1998.

Appendix V. 1999 harbor seal aerial survey counts from the Kodiak trend route.

| Site # | Site Name | Aug-14 | Aug-15 | Aug-16 | Aug-17 | Aug-29 | Aug-31 | Sep-1 | Sep-2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Long I | 40 | 57 | 57 | 58 | 32 | 45 | 70 | 44 |
| 2 | Cliff Pt | 0 | 3 | 0 | 6 | 0 | 3 | 16 | 28 |
| 3 | Broad Pt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Kalsin B | 162 | 137 | 163 | 86 | 85 | 153 | 144 | 132 |
| 5 | Ugak I | 646 | 644 | 574 | 587 | 428 | 470 | 416 | 374 |
| 6 | W Pasagshak | 255 | 350 | 271 | 327 | 217 | 158 | 141 | |
| 7 | Upper Ugak B | 40 | 95 | 98 | 69 | 7 | 38 | 93 | 78 |
| 8 | Shearwater B | 92 | 105 | 105 | 103 | 102 | 102 | 134 | 94 |
| 10 | Black Pt | 220 | 220 | 163 | 204 | 172 | 224 | 230 | 174 |
| 11 | Rolling B | 45 | 51 | 37 | 63 | 46 | 50 | 33 | 16 |
| 12 | O Kaguyak | 6 | 6 | 7 | 11 | 3 | 0 | 2 | 3 |
| 13 | Geese I N | 339 | 345 | 369 | 342 | 178 | 249 | 199 | 329 |
| 14 | Mid Geese I | 32 | 48 | 89 | 65 | 31 | | 46 | 31 |
| 15 | S. Geese I | 71 | 37 | 39 | 34 | 34 | | 18 | 3 |
| 16 | Aiaktalik L | 31 | 20 | 24 | 28 | 25 | | 29 | |
| 17 | Aiaktalik I | 88 | 74 | 90 | 75 | 77 | | 111 | 97 |
| 18 | Sunstrom I | 25 | | 30 | 38 | 23 | | 15 | 14 |
| 19 | N Sitkinak Lgn | 155 | | 156 | 151 | 164 | | 144 | 147 |
| 20 | Sitkinak I SE | 289 | | 283 | 241 | 243 | | 243 | 276 |
| 21 | S Sitkinak Lgn | 0 | | 159 | 133 | 21 | | 112 | 205 |
| 22 | SE Tugidak Bars | 182 | 185 | 174 | 201 | 173 | | 128 | 107 |
| 23 | SW Tugidak | 708 | 888 | 900 | 661 | 928 | | 990 | 947 |
| 24 | N Tugidak (out) | 0 | | 0 | 0 | 133 | | 307 | 154 |
| 25 | NE Tugidak (out) | 371 | 254 | 270 | 256 | 202 | | 142 | 272 |
| 26 | Tugidak Lgn in | 427 | 405 | 345 | 369 | 240 | | 332 | 233 |
| 27 | NNE Tugidak (out) | 449 | 692 | 727 | 591 | 369 | | 290 | 211 |
| 28 | Upper Kiliuda | 72 | 90 | 83 | 91 | 48 | 48 | 107 | 82 |
| 29 | Women's Bay Mkr | 62 | 67 | 54 | 51 | 26 | 14 | 24 | 24 |
| 32 | I Kaguyak | 34 | 36 | 45 | 33 | 21 | 31 | 42 | 39 |

Note: Site #9 (Barnabas Rks) was not surveyed in 1999.